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Design of a Combined Ballistic Simulator and Primer Force Experimental Fixture

by Todd Dutton and Andrew Brant

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by Todd Dutton and Andrew Brant

Weapons and Materials Research Directorate, ARL

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14. ABSTRACT Two innovative methods used to research propellant ignition during the gun cycle have been combined into a single experimental fixture. The first experimental technique uses a transparent cylinder and high-speed video to record the ignition of propellant while recording pressurization. The second technique uses a force gauge behind the breech to measure the force acting in the primer cup, which should approximate breech pressure in the gun. These techniques have been combined for the first time and scaled to larger calibers than previously tested. The new fixture allows pressure to be measured where the base of the bullet would be in a gun and allows force acting in the primer cup to be measured while using a transparent chamber to view flame spreading. The experimental fixture was fabricated for firing 0.50-cal. Browning machine gun primers and propellant and systems that use large rifle primers. Initial experimental data and future adaptations of the fixture will be discussed.					
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Contents

List of Figures	iv
Acknowledgments	v
1. Introduction	1
2. Background	1
3. Technical Approach	4
3.1 Hardware Design	4
3.2 Experimental Setup	6
4. Results and Discussion	8
4.1 Current Study	8
4.2 Previous Studies	9
5. Conclusions and Future Work	13
6. References	15
Appendix. Fabrication Drawing List	17
Distribution List	33

List of Figures

Fig. 1	Small caliber ballistic simulator fixture	2
Fig. 2	Primer insert plate and large rifle primer. Cross-sectioned isometric view and breech view.....	3
Fig. 3	Primer force fixture with short gun barrel	4
Fig. 4	Combined primer force and ballistic simulator fixture, configured for 300 WM.	6
Fig. 5	Hybrid fixture data for 300 WM. Light percentage is relative to the second axis.	10
Fig. 6	Ballistic simulator and primer force data for M855A1 are compared. Light percentage is relative to the second axis.	11
Fig. 7	Ballistic simulator and primer force data for M80A1. Light percentage is relative to the second vertical axis.	13

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1. Introduction

Research on the ignition of gun propellants during the interior ballistic cycle has been a topic of interest for many years, and many experimental techniques have been designed. Two techniques were pioneered at the US Army Research Laboratory (ARL) and are frequently used in the Propulsion Science Branch. The first is the small caliber ballistic simulator (Williams and Brant 2007), and the second is the primer force fixture (Beyer and Colburn 2010). These experiments provide detailed information on the interaction of gun primers and propellants. A new experimental fixture was developed that combines the types of data collected from the separate experimental techniques into a single experiment. This allows seamless correlation of data without the inaccuracies and difficulties typical in comparing results from different experiments, inherently synchronizes all data, and provides more comprehensive ignition data. The new fixture allows experiments to be performed on larger caliber gun chambers than previous efforts—it is currently accommodating 0.50-cal. Browning machine gun (BMG) ammunition—and will be able to adapt to larger gun systems. An additional objective of the new design was to incorporate adaptability for future experiments, providing a fast and inexpensive means of improving and developing ARL’s experimental capability to study gun propellant ignition.

The new fixture was designed and fabricated at ARL, and initial experiments have been performed. The design of the fixture will be discussed, and the considerations, improvements, and capabilities included in the design will be elaborated. Data from the previous experimental fixtures will also be discussed, and an attempt to correlate the ignition data from similar experiments will be made. Data from the new hybrid fixture will then be presented and compared to illustrate the strengths and benefits of the new design. The experiments also provided insight into future improvement and experiments that can be performed with the adaptability designed into the fixture.

2. Background

Ballistic simulator experiments have been used for ignition research in many gun systems and many calibers. A frangible, transparent gun chamber has been used for direct observation of the ignition process in the initial stages of the ballistic cycle. This chamber bursts at an arbitrary pressure typically between 8,000 and 16,000 psi dependent on several variables. Data prior to chamber rupture can be analyzed to determine characteristics of the primer and propellant, though the burst pressure and behavior is not intrinsically useful data due to the lack of repeatability in the

chamber material performance. The cylindrical chamber can be filled with different propellants, inert material, or left empty; various ignition systems can be examined as well. The details herein pertain to the small caliber ballistic simulator fixture designed and fabricated at ARL (Williams et al. 2006). It has been used to study small caliber systems initiated by small and large rifle primers by varying the propellants and types of primer used. Experimental data recorded in this fixture was from earlier unpublished experiments performed by Anthony Williams and Andrew Brant of ARL (Brant 2012). The main materials discussed are No. 41 primers, No. 34 primers, and SMP 842 propellants. The chambers were fabricated to match the volume of M855A1 and M80A1 ammunition, though cylinders of various sizes could be placed in the fixture to simulate many different gun systems. A Kistler 211B pressure transducer is located where the rear end of the bullet would rest in a gun cartridge, and pressure is measured through a small port aligned axially with the chamber. The breech end of the chamber is threaded for the insertion of a small plate that is fabricated to replicate the cartridge geometry of interest. The plate has several features machined into it; a primer cup, a spit-hole, and the rear of the cartridge case. A schematic of the ballistic simulator fixture can be seen in Fig. 1, and an image of a primer insert plate can be seen in Fig. 2.

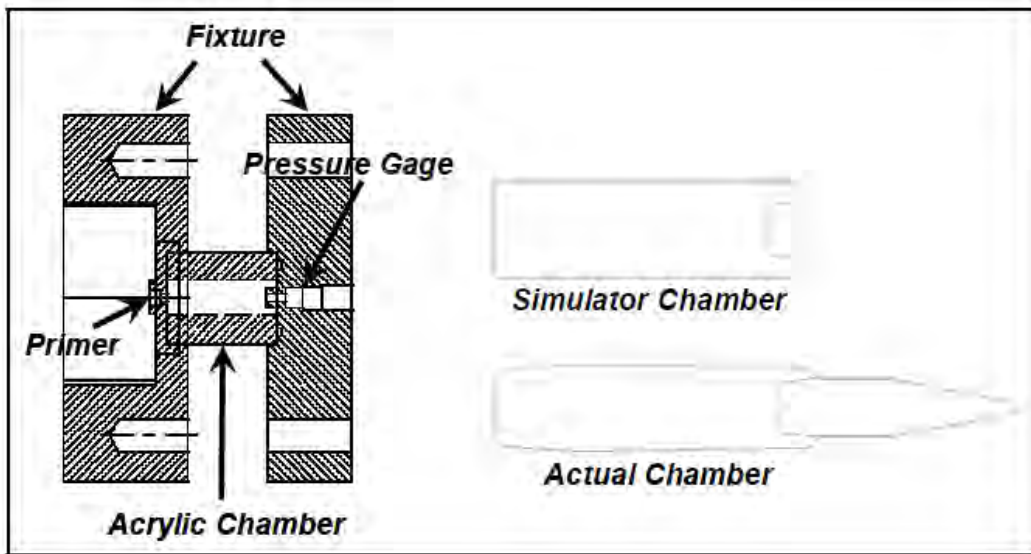


Fig. 1 Small caliber ballistic simulator fixture (Williams et al. 2006)

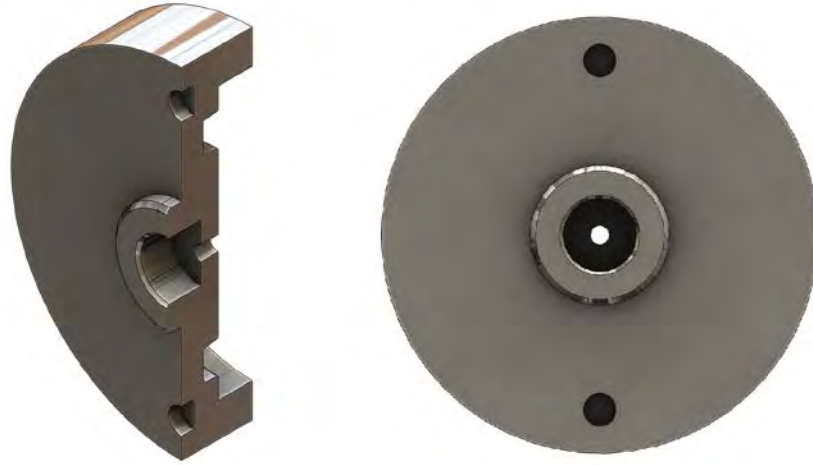


Fig. 2 Primer insert plate and large rifle primer. Cross-sectioned isometric view and breech view.

The data collected from this experimental fixture reveal many details of the ignition process. Primer function and output characteristics can be analyzed in isolation or observed interacting with inert or energetic propellant. Flame-spreading rates of various propellants can be measured, and bed compaction behavior can be observed. Early pressurization in the gun chamber is simulated, but the chamber will burst typically between 8,000 and 16,000 psi, or about 20%–30% of the maximum operating pressure. There is also some discrepancy in pressurization and compaction behavior because there is a fixed boundary instead of a moveable bullet at the end of the chamber opposite the primer. The experiment records detailed data during the first 0.1 ms of propellant ignition, so this static boundary is assumed to have a negligible effect. The ballistic simulator fixture provides excellent data as a comparative tool for many ignition variables that can be manipulated.

The other experimental fixture used frequently is the primer force fixture. It allows the force acting on the primer cup to be measured by fabricating a freestanding section of the breech face and placing a force gauge behind it. This section of the breech is directly behind the primer with a channel allowing the firing pin to pass through. The force acting on the inside of the primer cup is transferred through the primer and along the freestanding breech section to the force gauge (Fig. 3). Mid-case pressure can also be measured with this experimental fixture, and good agreement between these pressure measurement locations can be seen in much of the data. Valuable firing pin timing and loading rate data are also clearly shown from the force gauge. The primer force fixture uses a standard gun chamber modified by the addition of a pressure port but with a bespoke breech. This allows gun firings with full bore travel to be performed, and data can be collected across the entire interior ballistic cycle. A very short gun barrel can also attach to the

primer force fixture, which exposes the front end of the bullet beyond the end of the barrel. High-speed video records can then be used to measure the initial motion of the bullet with high accuracy. The primer force fixture with the short gun barrel attached can be seen in Fig. 3.

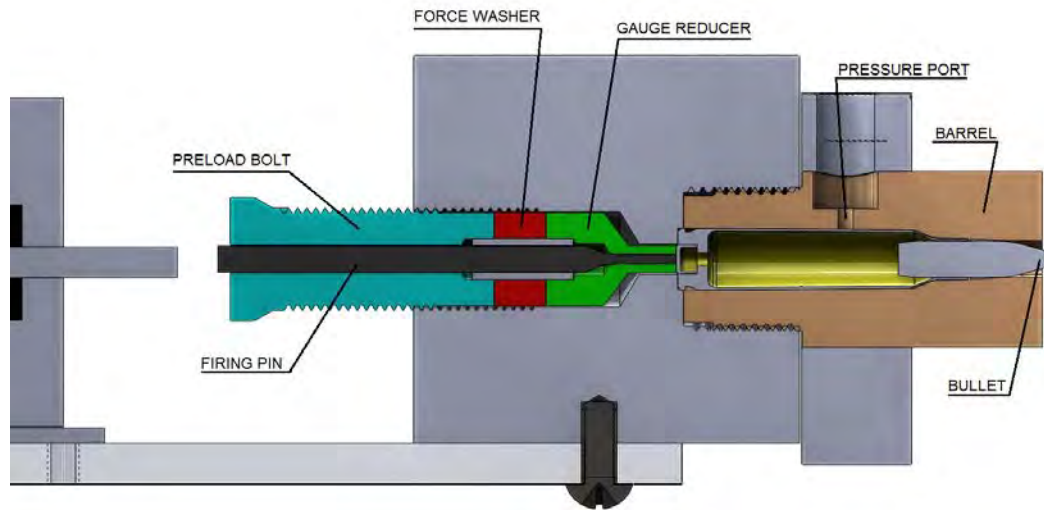


Fig. 3 Primer force fixture with short gun barrel (Beyer and Colburn 2010)

3. Technical Approach

3.1 Hardware Design

A new fixture was initially desired to increase the caliber of ballistic simulator experiments beyond 5.56- and 7.62-mm small caliber gun systems. No fixture existed with the capacity to study 0.50-caliber BMG or 0.300-cal. (300) Winchester Magnum (WM) ammunition for either primer force or ballistic simulator experiments. While designing this larger scale ballistic simulator fixture, several design improvements and modifications were made. One of the main design changes was the decision to incorporate primer force data into the new fixture. It was also proposed that synchronized primer force and ballistic simulator data would be valuable in a single experiment and could rectify discrepancies seen using 5.56-mm ammunition. Creating a fixture that combined both experiments into one could be used to determine a more complete picture of propellant ignition and alleviate any disagreement. The new design also incorporated features to ease the loading process and improve chamber sealing and repeatability.

The combined fixture was designed to draw together components from the previous experiments: the chamber section was based on the ballistic simulator fixture, and the breech was based on the primer force fixture. This new hybrid design allows

high-speed video of the ignition while pressure and force histories are recorded. The data illustrate the movement and compaction of the propellant bed, the behavior of gas pressurization at both ends of the chamber, and the ignition of propellant throughout. These data can be correlated and compared directly with a common timing signal. The firing pin loading rate, including highly resolved measurement of the primer initiation, is also captured in the primer force data. A secondary measurement of firing pin strike timing was incorporated by electrically isolating the firing pin from the solenoid striker. This acts as a switch closure when the firing pin is struck, giving a clear timing signal.

Modifications were made to the designs of the previous fixtures to improve data quality and ease of use for the new fixture. The primer force fixture produced data that would often have a strong periodic oscillation throughout the data. Experiments were performed to determine the source of this ringing, and the threads between the preload bolt and breech, and between the breech and chamber, were found to be too loose. When heavy grease or Teflon tape was used to tighten the interface between these threads, the vibration signal in the data decreased as it was damped. The new fixture was designed with tighter thread pitches for both interfaces and specified with Class 2 threads since the breech must be removed for loading. Class 3 threads were considered but would increase the difficulty of removing and tightening the breech. The preload bolt does not have to be removed between firing and in future designs could use Class 3 threads for a tighter fit. One other consideration was addressed that was unique to the hybrid experimental fixture: as the breech was tightened it could loosen the primer plate, so left-handed threads were machined on the primer plate.

The ballistic simulator fixture was occasionally time consuming to load due to a bolt pattern that did not constrain the parallelism of the plates. Calipers were used to measure the distance between the plates on all sides as the bolts were tightened to ensure the chamber was evenly sealed. For the new hybrid fixture shoulder bolts were machined to a specific length to ensure the bolts tighten evenly, sealing the chamber between 2 O-rings. Six bolts were used instead of the previous 4, improving the force distribution around the chamber seal. These changes allowed the fixture to be loaded and assembled more quickly and sealed more reliably. The hybrid fixture can be seen in Fig. 4. The full drawing package can be found in the Appendix.

One other design consideration allows for using interchangeable parts. The fixture was initially fabricated with the parts necessary to fire 300 WM and 0.50-cal. BMG primers and propellants. Chambers of various sizes, and a small number of additional parts, can be fabricated to allow a broad range of primers and propellants to be fired in the fixture, simulating many different gun systems. The design also

includes the ability to adapt to future experiments. The pressure gauge port is removable, allowing various other attachments to be added in its place. For example, a short gun barrel similar to the one used with the current primer force fixture is planned for fabrication to study early bullet motion. An additional part was designed to allow primers smaller than 0.50-cal. BMG to be loaded into primer plates and interface properly with the breech. This reloading jig aligns the primer in the plate, allowing it to be fully seated quickly and easily.

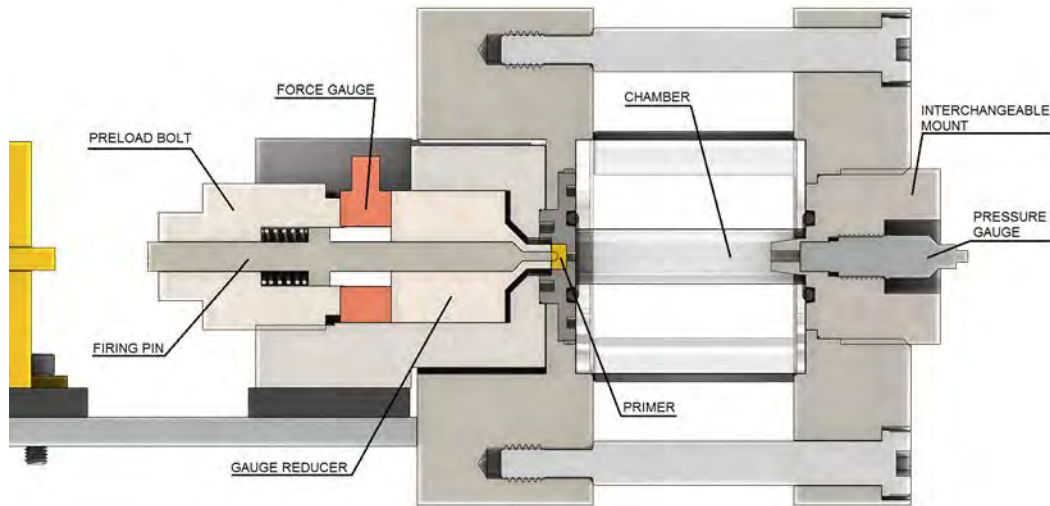


Fig. 4 Combined primer force and ballistic simulator fixture, configured for 300 WM.

3.2 Experimental Setup

Initial experiments in the hybrid fixture were performed using MK248 (300 WM) ammunition. This ammunition was disassembled and the propellant was unloaded. No. 43 large rifle primers were used from inventory. The fixture was partially disassembled for loading, removing the breech and firing solenoid quickly with the aid of interrupted threads. The 6 mounting bolts were also taken out and the end plate, chamber, and primer plate were removed. The No. 43 primers were seated into the primer plate using the loading jig, and then the plate was tightened counter-clockwise into the fixture mount. The empty chambers had a volume of 5.165 cc, which closely replicated the volume inside of a 300 WM cartridge. A greased O-ring was placed in the primer plate groove, and the empty chamber was seated fully into the recess around the primer plate. The pressure transducer used was a Kistler 607C, and between every shot it was removed and high-melting-point grease was reapplied to fill the pressure port channel and remove any voids. The pressure gauge was seated with a torque of 20 ft-lb, and another greased O-ring was inserted into the groove on the interchangeable mount block, which was then tightened into the end plate. The propellant unloaded from the 300 WM cartridges was then poured

into the chamber, which was tapped lightly to encourage the propellant to settle. The experiments that were performed to gather this data were part of a separate effort, and only limited data will be reported here. Though outside the purview of this report, valuable information was gained on using various propellants. One of the systems being studied had very high loading density, and one of the types of propellant required a certain amount of compression to load the chamber properly. The propellant bed needed to be settled adequately to allow the boat tail on the pressure gauge block to be inserted without the chamber overflowing. Once this was achieved the end plate assembly was seated firmly over the chamber, and the 6 mounting bolts were tightened in a crossing pattern to 100 inch-lb.

An adjustment to the fixture was made after the second shot, during which early blow-by from the chamber was noted and the chamber remained partially intact. It was hypothesized that the shoulder bolts were tightening on their shoulders slightly before the chamber tightened fully on the end plates, reducing the sealing force on the chamber. O-rings of the appropriate size were used as washers under the bolt heads and effectively shortened the shoulders of the bolts. This allowed the chamber to be sealed more tightly while providing elasticity to prevent it from being crushed. Subsequent shots did not show early blow-by in the same manner.

Once the bolts were tightened the fixture was mounted in a firing stand and the data cables and breech were attached. The force gauge used in the breech assembly was a Kistler 9031A. The breech uses interrupted threads to ease assembly, but the spring loaded gauge reducer and firing pin complicate this slightly. The preload bolt must be unscrewed to a certain point such that it allows the spring to compress. This will allow the interrupted threads to engage freely, and the breech should tighten clocked near 12 o'clock. Also, the firing pin is protruding from the breech face toward the primer as it is inserted, so the procedure must be performed slowly and with care. Once the breech is tightened by hand the preload bolt then must be tightened while monitoring the measured force acting on the force gauge. A digital multimeter was connected to the force gauge signal amplifier to measure the output voltage, which was zeroed before any force was applied. The preload bolt was then slowly tightened until a constant voltage between 0.3 and 0.4 V is read, indicating firm contact along the force train from primer to force gauge. This provides a positive offset for the force gauge, allowing the firing pin loading rate to be measured and ensures that there is no air gap which would interfere with data collection. Then the firing line was plugged in and the solenoid plunger was inserted.

For these experiments the firing pin switch closure was not used for timing measurement. Two Phantom V7.3 high-speed cameras recorded the ignition event. The first, a color camera, was placed perpendicular to the shot line at a distance of

24 inches and focused on the chamber. It recorded at a frame rate of 81,632 fps, a resolution of 240×88 , and used a 50-mm lens with an aperture of f/1.4. The second camera recorded black and white video and was moved, and the lenses were changed during the experiments. It was generally used to focus on the brightest portions of the igniting propellant bed and had the aperture set to f/5.6.

4. Results and Discussion

These data were not used to draw broader conclusions about ignition but rather to verify that the new fixture provided reproducible and realistic data, and to facilitate comparison between data sets from previous experiments. Results from the new experiments are shown later in this report and confirm the new hybrid fixture is operating correctly. Experimental data from the small caliber ballistic simulator and the primer force fixture are also shown and compared. It is difficult to obtain a direct comparison between earlier experiments fired in separate fixtures and the current experiments from the hybrid fixture. Differences in caliber, chamber volume, ullage, and propellant type create unique pressurization behaviors for each gun system. Rough comparisons can be made between the timing of specific events in the ignition process, if not the magnitudes. Even so, ullage and primer strength have been shown to have a large impact on flame spread and ignition. Data were used to provide direct comparisons between the small caliber ballistic simulator and primer force fixtures for M855A1 and M80A1 ammunition. Data from the hybrid fixture represents MK248 ammunition. The primer force data were scaled to approximate breech pressure by dividing the measured force by the bearing surface area of the pressurized gases, i.e., the inner area of the primer. This method has been shown to correlate well with measured and predicted gun pressures (Beyer and Colburn 2010). Records of propellant ignition (light output) are determined by measuring the spatial propagation of light in the chamber as a percentage of the entire chamber length.

4.1 Current Study

The hybrid ballistic simulator/primer force fixture removes much of the uncertainty when comparing and synchronizing data from the previous experiments; the timing of events in the ignition process is fully defined. Initial experiments with the hybrid fixture fired No. 43 primers into SMP 842 propellant in a chamber matching the internal volume of a 300 WM. The loading density and chamber volume greatly change the ignition process, so these data cannot be directly compared with the other data sets shown below. Figure 5 shows the results from the initial firing of this fixture. Certain areas of interest should be noted. Timing has been shifted such that zero corresponds to the first decrease in preload due to the firing pin impact on

the primer. The loading rate of the firing pin pushing into the primer can be seen in the initial downward slope of primer force data. The initiation of the primer can then be seen by the sharp rise in force. This coincides precisely with the time at which the first light is visible in the chamber on high-speed video record. Shortly after this point, the pressure rises sharply on the far end of the chamber due primarily to propellant bed compaction. This can be seen in the flame spread data as the flame front slows and regresses slightly at 0.00033 s, until the compacted bed relaxes. This relaxation occurs just after the pressure decreases at 0.00035 s, the primer force value remains quasi-static, the ignition record slope becomes positive at 0.00035 s, and then sharply increases at 0.00040 s. A second rise in pressure follows, leading to chamber rupture. This rise is caused by the accelerated ignition of the relaxing propellant bed producing a great deal of gas phase pressure, which can be seen in the data from both ends of the chamber. Mid-case pressure data from the hybrid fixture would be a valuable comparison tool and may be incorporated into the hybrid fixture in the future.

4.2 Previous Studies

Few ammunition types have been fired in both fixtures since the primer force fixture is especially new, and ballistic simulator studies of small caliber systems have only been a recent area of interest. Experiments using No. 41 primers and SMP 842 propellant with the chamber volume of a 5.56-mm M855A1 have been fired in both fixtures (Ritter et al. 2012), and these data provide one point of commonality between fixtures. Figure 5 shows the pressurization and spread of light in the chamber from the small caliber ballistic simulator experiments on the same axes as the primer force and mid-case pressure data from the primer force experiments (Ritter et al. 2013; Dutton 2014).

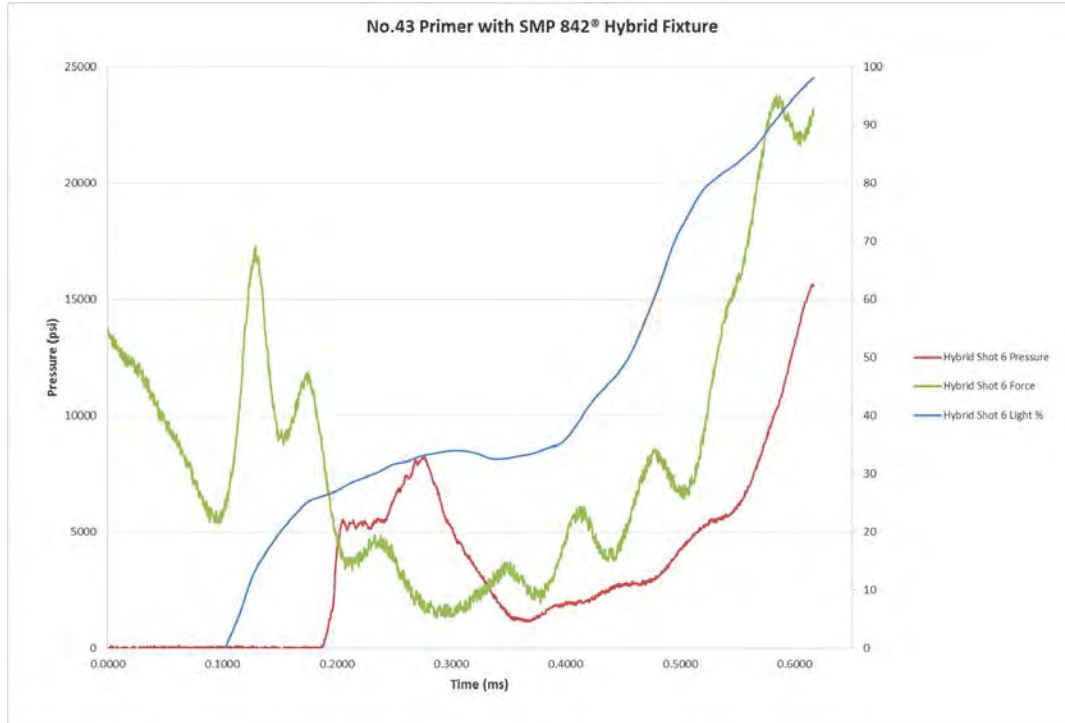


Fig. 5 Hybrid fixture data for 300 WM. Light percentage is relative to the second axis.

In earlier studies, the timing of the data was synchronized using the first drop in the preload force from the primer force experiment in conjunction with the switch closure from the solenoid striking the firing pin in the ballistic simulator. Both of these metrics should represent the first contact between the firing pin and the primer and allow direct comparison of the data. Conversely, the Hybrid fixture data in Fig. 5 shows the close relationship between initial light output and primer force output. When testing both methods of synchronization, it was found that the second method was much more accurate and repeatable. The primer force data was aligned at zero in the same manner as the previous graph; the first drop in primer force preload was shifted to intersect the y axis. From this point, the primer force preload can be seen decreasing as the firing pin presses into the primer, reducing the force on the gauge. As the preload decreases to a minimum and starts to increase, the first light from the primer can be seen. Recall that these data are from 2 separate experiments plotted as though they occurred concurrently, unlike the previous graph which showed a data from a single experiment. Shortly after first light the primer force slopes upward sharply and a double hump is formed. The second hump is believed to be a reflection of primer output from the granular propellant bed. After the initial hump in primer force, pressure can be seen to rise in the ballistic simulator pressure transducer. This transducer is located at the location of the bullet boat tail in a typical cartridge, and the pressure port is filled with grease. The grease allows the measurement of pressure from the solid-phase propellant bed

compaction before gas pressure spreads through the chamber. While the initial pressure rise is likely due to bed compaction, it is quickly surpassed as propellant ignition spreads and gas generation dominates the pressure rise, causing the chamber to burst. The ballistic simulator pressure and light records are truncated at this point in Fig. 6. The primer force experiments are not performed in frangible chambers, so mid-case pressure and primer force continue to be recorded. This can be seen as the pressure and force continue to rise, during which time the bullet travels down the gun barrel. A significant periodic oscillation was noted in the primer force data, though it is not shown in Fig. 6. It was likely caused by vibrations in the fixture, which is an issue the new fixture was designed to remedy.

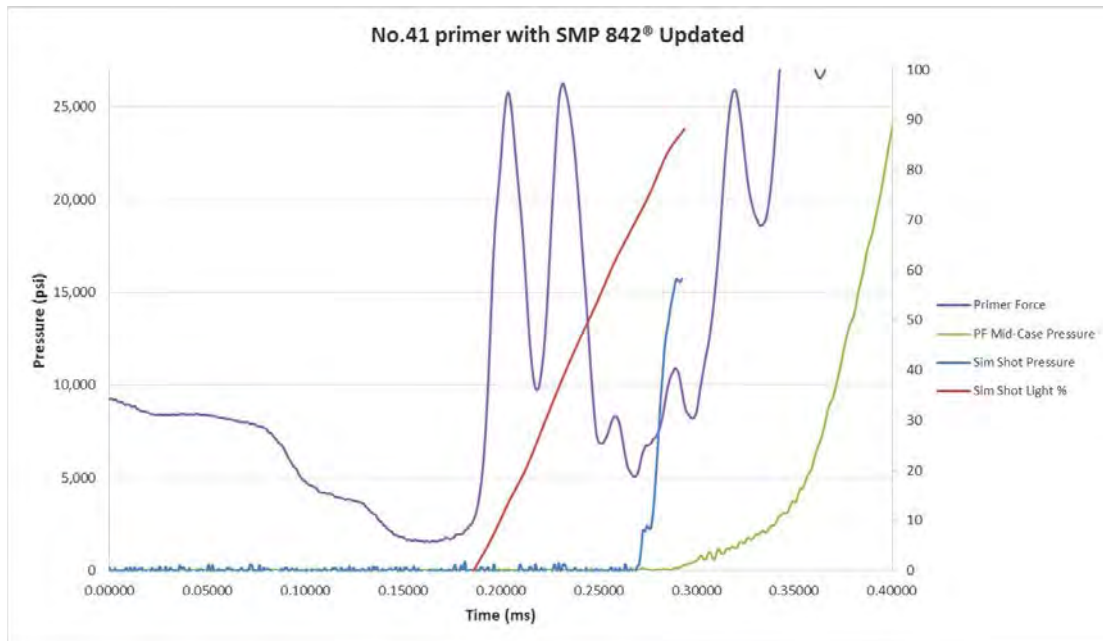


Fig. 6 Ballistic simulator and primer force data for M855A1 are compared. Light percentage is relative to the second axis.

A discrepancy exists between the 2 experiments when the ballistic simulator chamber has over pressurized and burst, but the primer force mid-case pressure measurement shows no pressurization. Gas pressure should be present throughout the chamber at the point of rupture, which is corroborated by high-speed video of the fully ignited propellant and by separate experiments. These previous experiments verified propellant gas production causes the frangible chamber to burst, not primer output alone. Empty and inert-filled chambers fired with only the primer survived intact, indicating that propellant gas production contributes to the pressurization and causes the chamber to burst. The pressure rise discrepancy may stem from several experimental factors. The mid-case pressure port is not greased and will not record solid particle compression of the propellant, and the alignment of the mid-case pressure port is perpendicular to the shot line, which influences the

pressurization data. The data could also be influenced by the fixed boundary at the end of the chamber in place of a moveable bullet. The transparent chamber internal volume is also believed to significantly expand during pressurization when compared with a gun chamber, and a slightly larger amount of ullage is present in the simulator shots. Future experiments are planned to further investigate this discrepancy.

Experiments using No. 34 primers, SMP 842, and chamber volume representing M80A1 ammunition showed markedly different records of pressures and forces (Brant 2012; Ritter 2014). These experiments were also performed in the 2 separate experimental fixtures, and the data is shown Fig. 7 using the 2 synchronization method as the data in Fig. 6. The primer force data show the decrease in static preload and the initiation of the primer with a characteristic double-hump feature. Light from ignited propellant can be seen on the high-speed video from the simulator near 0.00015 s, and flame spread behavior is highly linear. The propellant does not fully ignite in this experiment; the chamber bursts when 42% of the propellant appears ignited using the methodology described above. Mid-case pressure in the primer force fixture was not measured during these experiments, but past experiments have shown that it trends closely to the scaled primer force data, though slightly later in time. The delay between first light rise and first pressure rise is expected, though the delay until primer force increases, indicating gas pressurization of the chamber, is a similar anomaly to what was seen in Fig. 6. The same sources of error as described above apply to this experiment as well. Throughout the experiments using the 7.62-mm primer force fixture, severe vibrations were recorded. Figure 6 has been truncated and does not show these oscillations, which were greater in magnitude than those seen in the 5.56-mm primer force data.

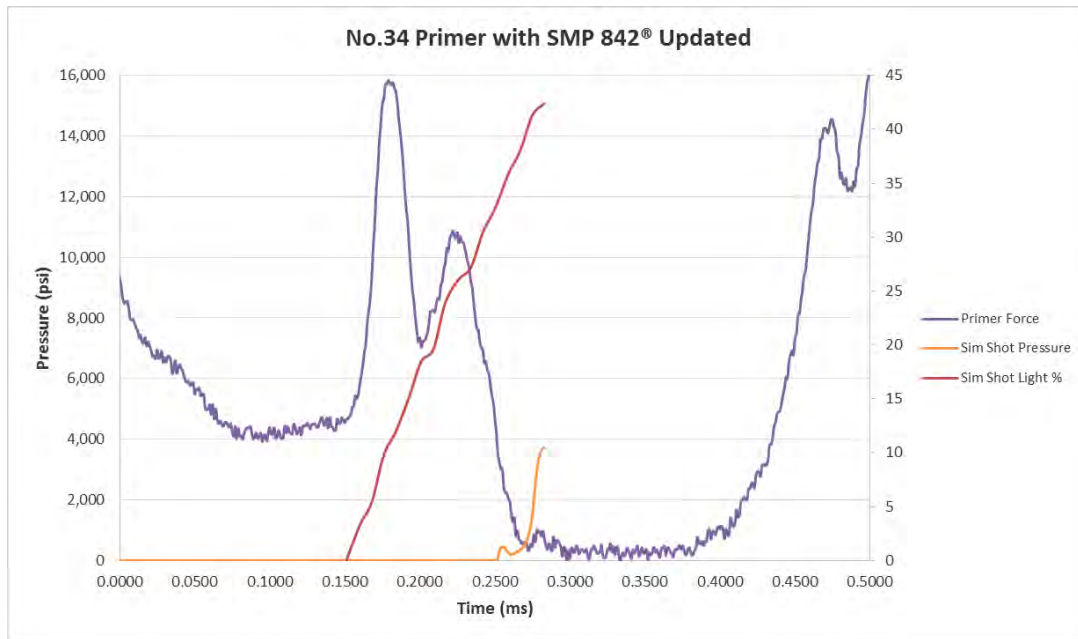


Fig. 7 Ballistic simulator and primer force data for M80A1. Light percentage is relative to the second vertical axis.

Without mid-case pressure it is difficult to ascertain the magnitude of the delay in pressure generation seen in the M80A1 firings. More data are required from experiments using the primer force and ballistic simulator experiments to allow a better characterization of ignition in M80A1 ammunition. Chambers could be fabricated to adapt the hybrid fixture to M80A1 specifications. Experiments have also not been performed to verify if the primer alone can rupture the M80A1 scale ballistic simulator chamber. It is hypothesized that gas pressure from ignited propellant is still required for this system, much like the M855A1, though the M80A1 chambers rupture at much lower pressures.

5. Conclusions and Future Work

The new combined ballistic simulator and primer force fixture has greatly enhanced the ability of the Propulsion Science Branch at ARL to analyze ignition processes in exact detail. The synchronization issues inherent in comparing 2 distinct experiments have been removed, and further research can now be conducted on early time interior ballistic phenomena. The data from the hybrid fixture clearly show the interaction of solid-phase bed compaction and gas-phase pressure with ignition. The improvements to the previous designs incorporated into this fixture appear to have improved the quality of data, enhanced repeatability of experiments, and eased the loading and firing process. Noise and vibration have been reduced, and a fast and repeatable chamber sealing method has been implemented. The new

fixture has shown promise in this initial experimental run, and it will be instrumental in future interior ballistic research.

Valuable insights could be gained if this experiment were extended to more realistically simulate a gun chamber. A short gun barrel attachment is planned for fabrication to mount in place of the axial pressure transducer, and an attempt will be made to add a radial mid-case pressure transducer. There is ongoing discussion regarding how a fixed boundary opposite the primer, instead of a moveable bullet, effects the ignition process. The short barrel attachment would allow a bullet to be loaded into the hybrid fixture such that propellant ignition and early motion could be observed and studied concurrently. There is also interest in researching off-axis bullet motion during engraving and its effect on weapon accuracy. A different attachment is planned for fabrication in place of the short barrel attachment, which will adapt the fixture for this experiment as well. Overall, the new hybrid gun simulator will be a very useful and adaptable tool for interior ballistic research. Machining drawings of the completed fixture can be found in the Appendix.

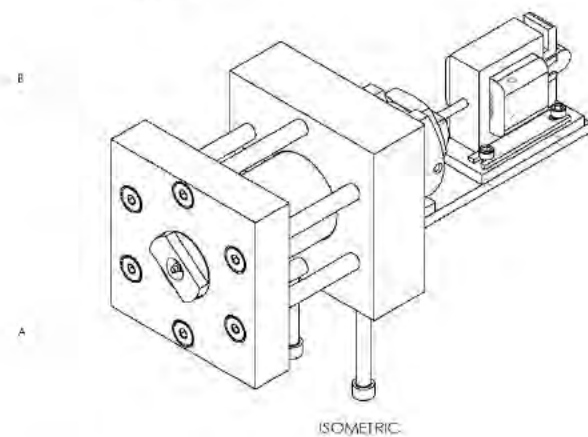
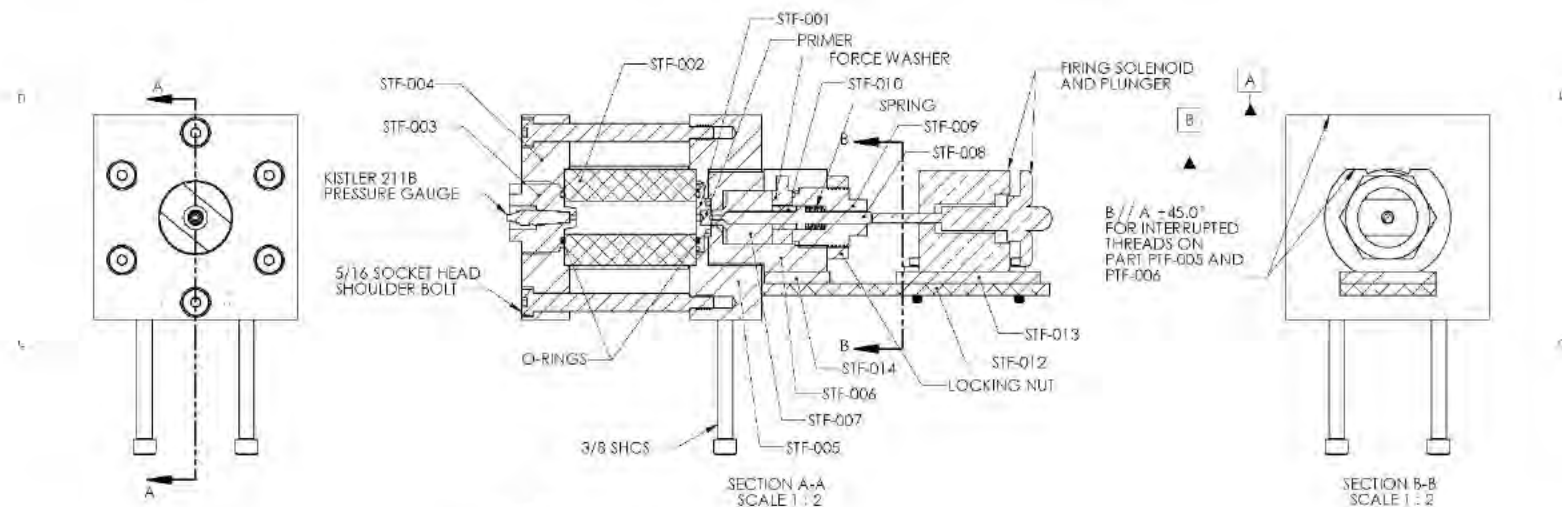
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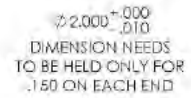
Appendix. Fabrication Drawing List

This appendix appears in its original form, without editorial change.



CONFIGURATION SHOWN FOR .50 CAL.
PARTS WITHOUT A DRAWING NUMBER WILL BE PURCHASED.

UNION SQUARE AND TOOL CO.	DATE: 1/00/12
DESIGNED BY: J. J. JONES	DESIGNED BY: J. J. JONES
ENGINEER: J. J. JONES	ENGINEER: J. J. JONES
MANUFACTURED BY: J. J. JONES	MANUFACTURED BY: J. J. JONES
TESTED BY: J. J. JONES	TESTED BY: J. J. JONES
DATE: 1/00/12	DATE: 1/00/12
SIZE: B	SCALE: 1:2 WEIGHT: 1
DWG. NO.: D-STF-011	REV: 1
SHEET 1 OF 1	



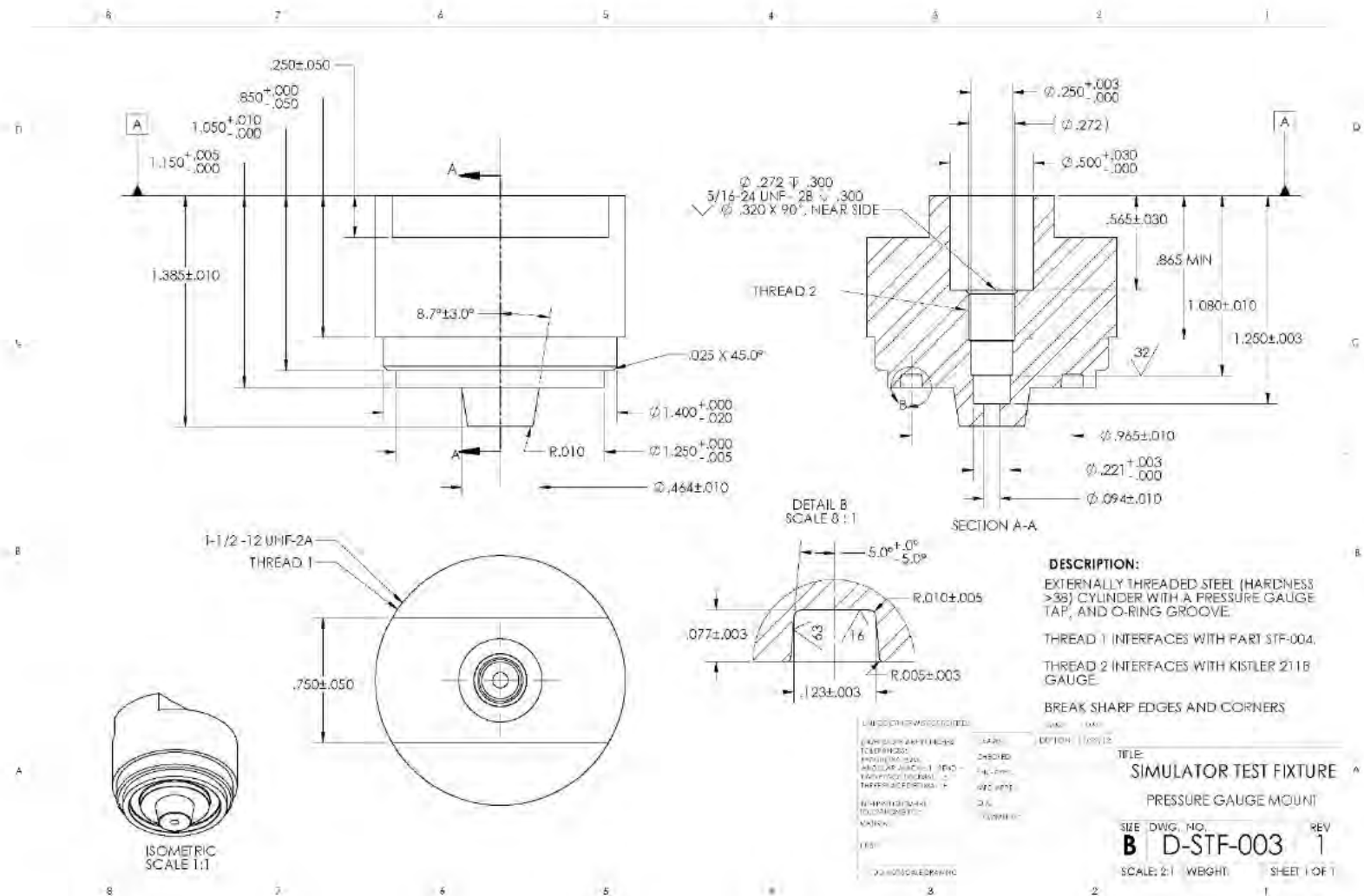
DESCRIPTION:

INTERFACES WITH PTF-D04 AND PTF-005

Ligand-Dependent Activation	
1. Ligand binds to the receptor	2. Receptor is activated
3. Receptor recruits signaling proteins	4. Signaling cascade is initiated
5. Signaling cascade leads to cellular response	6. Cellular response is executed

DATE	00/00/00
DEFINITION	1/00012

SIZE DWG. NO. REV
B D-PTF-002 1
SCALE: 1:1 WEIGHT: SHEET 1 OF 1



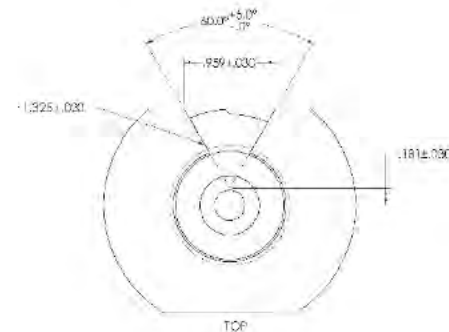
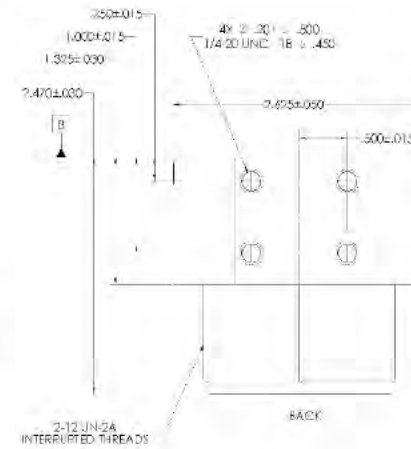
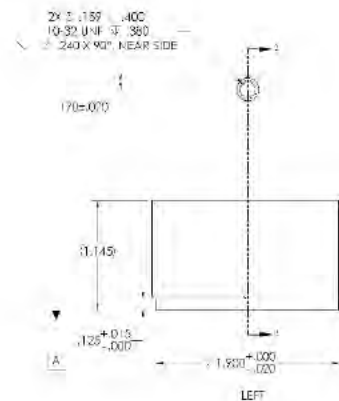
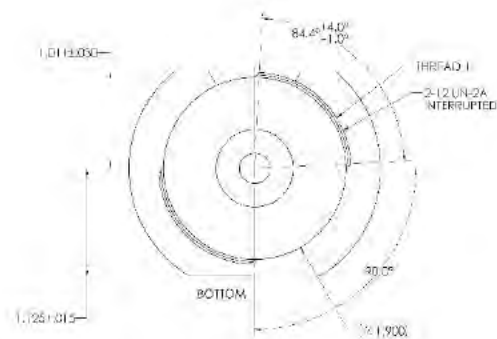
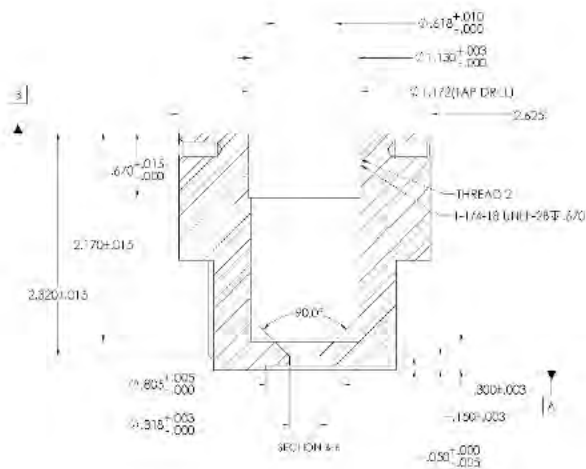


A STEEL BLOCK WITH A THREADED HOLE IN ONE SIDE, 6 COUNTERSUNK CLEARANCE HOLES, AND A FEATURE CUT ON THE OPPOSITE SIDE.

DATE OF THE REPORT	NAME	AGE
1998-01-01	John Doe	35
1998-01-01	Jane Smith	28
1998-01-01	Bob Johnson	42
1998-01-01	Alice Brown	31
1998-01-01	Charlie White	25
1998-01-01	Diana Green	38
1998-01-01	Frank Black	45
1998-01-01	Grace Hall	29
1998-01-01	Henry King	33
1998-01-01	Ivy Lee	27
1998-01-01	Jack Miller	40
1998-01-01	Karen Wilson	36
1998-01-01	Leo Taylor	30
1998-01-01	Mia Adams	24
1998-01-01	Noah Baker	39
1998-01-01	Olivia Clark	32
1998-01-01	Peter Evans	26
1998-01-01	Quinn Foster	41
1998-01-01	Rachel Gibson	34
1998-01-01	Samuel Hill	29
1998-01-01	Tina Jones	37
1998-01-01	Victor King	43
1998-01-01	Wendy Lee	31
1998-01-01	Xavier Miller	28
1998-01-01	Yvonne Wilson	35
1998-01-01	Zoe Taylor	23

22 MONSIEUR PAVINO



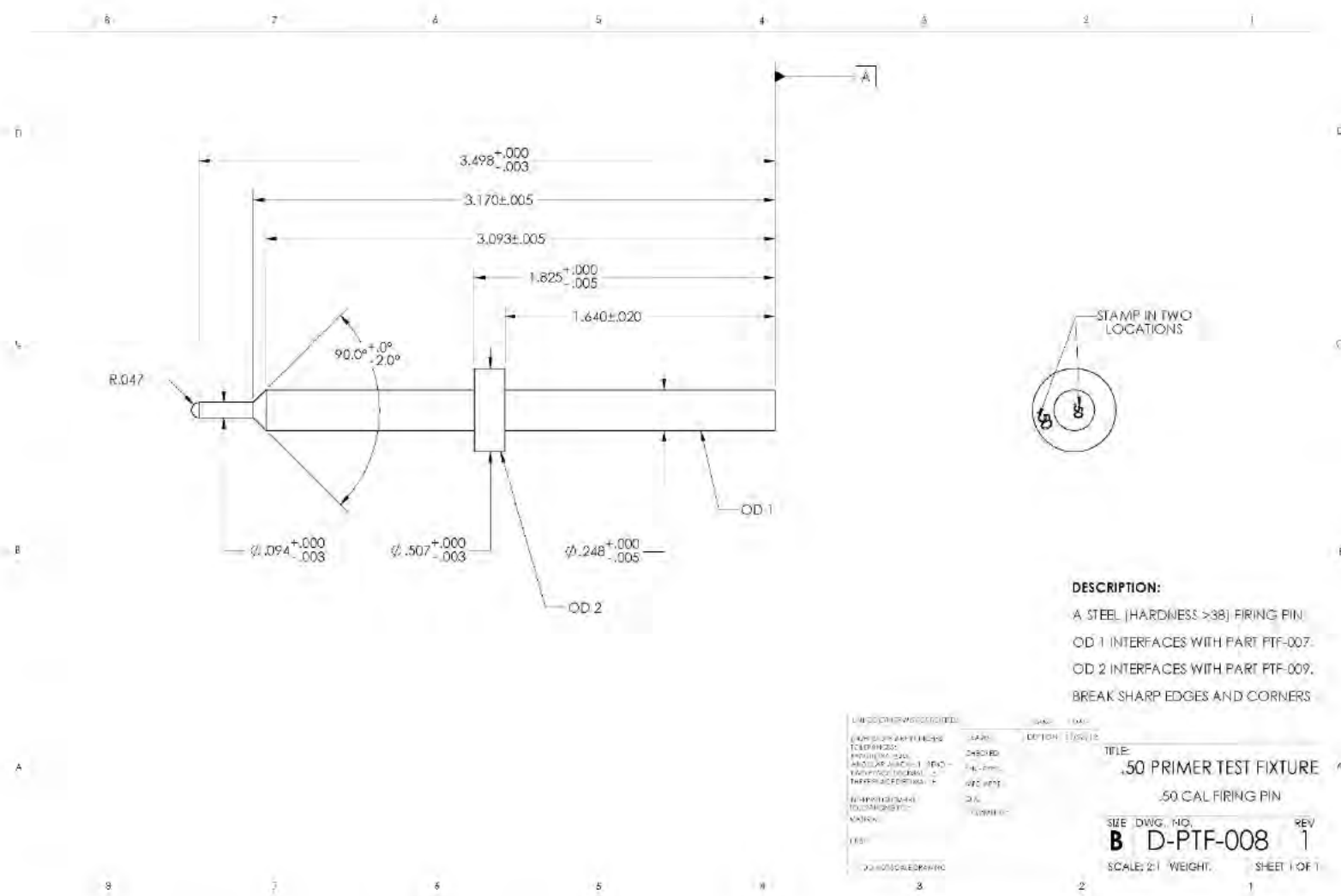


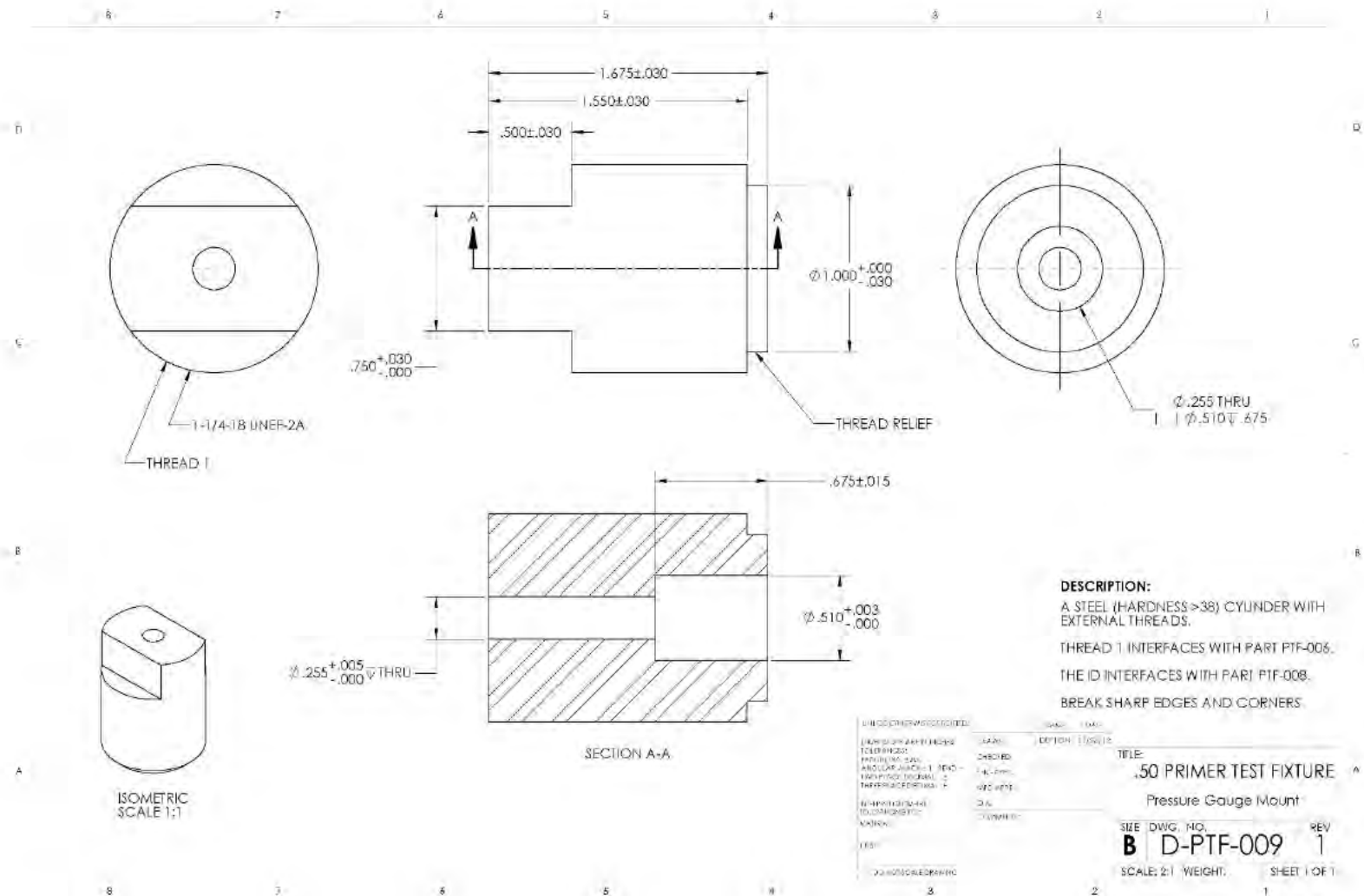
SOMETRIC

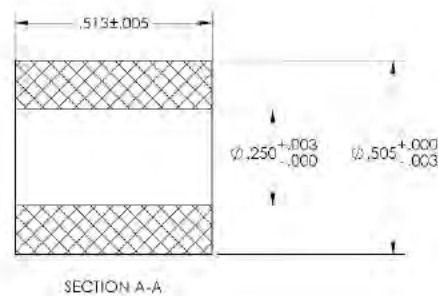
DISCUSSION:
AN INTERRUPTED THREAD STEEL
(HARDNESS 38) CYLINDER WITH AN
INTERNAL THREAD, A SLOT, AND
ASSORTED SCREW TAPS.
THREAD 1 INTERFACES WITH PART ST-
005. CLOSING SHOWN IN ST-011.
THREAD 2 INTERFACES WITH PART ST-
007.
BREAK SHARP EDGES AND CORNERS.

REV	DATE	BY	APP'D	DESCRIPTION
1	10/10/00	10/10/00	10/10/00	10/10/00
2	10/10/00	10/10/00	10/10/00	10/10/00
3	10/10/00	10/10/00	10/10/00	10/10/00
4	10/10/00	10/10/00	10/10/00	10/10/00
5	10/10/00	10/10/00	10/10/00	10/10/00
6	10/10/00	10/10/00	10/10/00	10/10/00
7	10/10/00	10/10/00	10/10/00	10/10/00
8	10/10/00	10/10/00	10/10/00	10/10/00
9	10/10/00	10/10/00	10/10/00	10/10/00
10	10/10/00	10/10/00	10/10/00	10/10/00

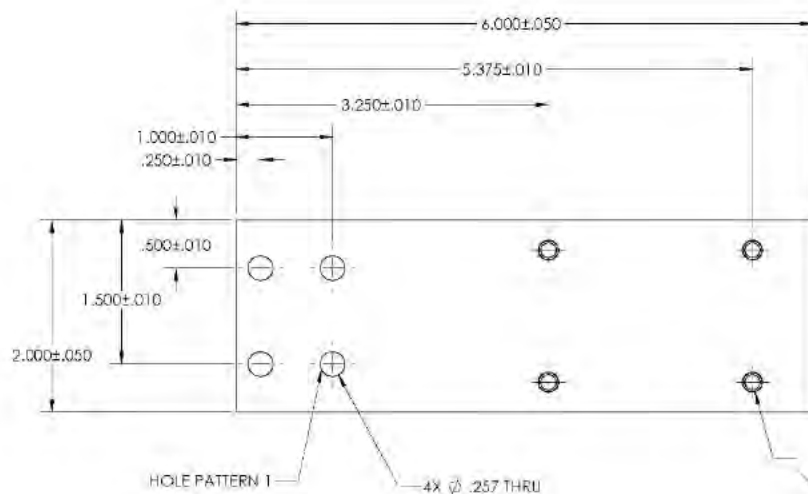
1/2
1/2 SIMULATOR TEST TEXTURE
Primer Force Inc.
D D-STF-006
10/10/00 10/10/00 10/10/00







SIZE DWG. NO. REV
B D-PTF-010 1
SCALE: 4" WEIGHT. SHEET 1 OF 1



4X Ø.159 THRU
10-32 UNF THRU
Ø.209 X .909, NEAR SIDE

HOLE PATTERN 1

4X Ø.257 THRU

DESCRIPTION:

AN ALUMINUM PLATE WITH TWO
SETS OF HOLES, ONE TAPPED AND
ONE CLEARANCE.

HOLE PATTERN 1 INTERFACES WITH
PARTS PTF-006 AND PTF-013.

BREAK SHARP EDGES AND CORNERS

UNSCHEMATIC		DATE	1/1/11
DESIGNED BY: J. J. J.	CHECKED BY: J. J. J.	DATE: 1/1/11	TIME: 1:00 PM
PROJECT: 1000	DESCRIPTION: .50 PRIMER TEST FIXTURE	DATE: 1/1/11	TIME: 1:00 PM
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REVISION: 2	REVISION: 2	DATE: 1/1/11	TIME: 1:00 PM
REVISION: 3	REVISION: 3	DATE: 1/1/11	TIME: 1:00 PM
REVISION: 4	REVISION: 4	DATE: 1/1/11	TIME: 1:00 PM
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REVISION: 7	REVISION: 7	DATE: 1/1/11	TIME: 1:00 PM
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TITLE:
.50 PRIMER TEST FIXTURE
 SOLENOID PLATE

SIZE DWG. HQ. REV
B D-PTF-012 1
 SCALE: 1:1 WEIGHT: SHEET 1 OF 1

1 DEFENSE TECHNICAL
(PDF) INFORMATION CTR
DTIC OCA

2 DIRECTOR
(PDF) US ARMY RESEARCH LAB
RDRL CIO LL
IMAL HRA MAIL & RECORDS
MGMT

1 GOVT PRINTG OFC
(PDF) A MALHOTRA

2 COMMANDER
(PDF) US ARMY ARDEC
AMSRD AAR AEE W
E CARAVACA
C ADAM

1 COMMANDER
(PDF) US ARMY ARDEC
RDAR MEM I
D GUBERNAT

25 DIR USARL
(PDF) RDRL WML
M ZOLTOSKI
RDRL WML A
W OBERLE
RDRL WML C
S AUBERT
RDRL WML D
R BEYER
A BRANT
J COLBURN
P CONROY
S HOWARD
M NUSCA
J RITTER
J SCHMIDT
A WILLIAMS
Z WINGARD
RDRL WML E
P WEINACHT
RDRL WML G
J SOUTH
T BROSSEAU
A MICHLIN
RDRL WML H
J NEWILL
T EHLERS
T FARRAND
L MAGNESS
RDRL WMM B
R KASTE

RDRL WMM C
P KASTE
RDRL WMP
D LYON